Comparison of Surface and Column Variations of CO_2 over Urban Areas for Future Active Remote CO_2 sensors

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High resolution in-situ CO_2 measurements were recorded onboard the NASA P-3B during the DISCOVER-AQ (Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality) Field Campaign, to investigate the ability of space-based observations to accurately assess near surface conditions related to air quality. This campaign includes, Washington DC/Baltimore, MD (July 2011), San Joaquin Valley, CA (January – February 2013), Houston, TX (September 2013), and Denver, CO (July-August 2014). Each of these campaigns consisted of missed approaches and approximately two hundred vertical soundings of CO_2 within the lower troposphere (surface to about 5 km). In this study, surface (0 – 1 km) and column-averaged (0 – 3.5 km) CO_2 mixing ratio values from the vertical soundings in the four geographically different urban areas are used to investigate the temporal and spatial variability of CO_2 within the different urban atmospheric emission environments. Tracers such as CO, CH_2O, NO_x, and NMHCs are used to identify the source of CO_2 variations in the urban sites. Additionally, we apply nominal CO_2 column weighting functions for potential future active remote CO_2 sensors operating in the 1.57-μm and 2.05-μm measurement regions to convert the in situ CO_2 vertical mixing ratio profiles to variations in CO_2 column optical depths, which is what the active remote sensors actually measure. Using statistics calculated from the optical depths at each urban site measured during the DISCOVER-AQ field campaign and for each nominal weighting function, we investigate the natural variability of CO_2 columns in the lower troposphere; relate the CO_2 column variability to the urban surface emissions; and show the measurement requirements for the future ASCENDS (Active Sensing of CO_2 Emissions over Nights, Days, and Seasons) in the continental U.S. urban areas.